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Don't waste waterweeds

Water hyacinth, which clogs rivers, ditches and canals throughout Africa and Asia as well as in the southern US, is being investigated by NASA as a means of treating effluents, producing biogas and fertiliser, and feeding livestock

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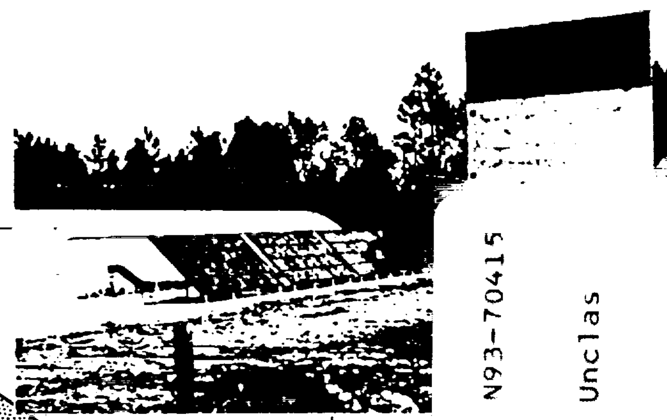
Japanese exhibitors coming to the 1884 Cotton Exposition in New Orleans brought with them an attractive water hyacinth they had collected from a river in Venezuela. It escaped—and today many of the world's major rivers between 32°N and 32°S latitude are infested with this beautiful pest (*Eichhornia crasspipes*).

Highly prolific and reproducing mainly by vegetative offspring, water hyacinths can double in number every 8-10 days in warm nutrient-enriched waters, forming huge solid floating mats. The plant consists of a fleshy, vertical stem called a rhizome, from which roots, leaves and flowers develop. The rhizome floats just beneath the water, where it is protected by shields of folded leaves, remaining alive when frost kills the surface leaves. Unless the water freezes, viable rhizomes will respond to warm water (10°C or greater) by producing new growth.

After its introduction into the United States, water hyacinths reproduced so rapidly that within only a few years rivers and streams in Louisiana and Florida were completely clogged with mats of plant material. The US Army Corps of Engineers was given the task of controlling this new noxious weed. In the early 1900s it started using sodium arsenite, but the hazards associated with this chemical were eventually recognised and in 1937 it was abandoned in favour of mechanical harvesting. After 10 years of a losing battle, the Corps of Engineers turned to the plant hormone 2,4-D when it became available in the late 1940s. For over 25 years this herbicide alone has been used in an effort to control *Eichhornia*.

In 1973 water hyacinths infested approximately 200 000 hectares of Lousiana water, and by 1975 the affected area



NASA research into the water hyacinth suggests a model farm where organic wastes are converted into biogas, fertiliser and animal feed

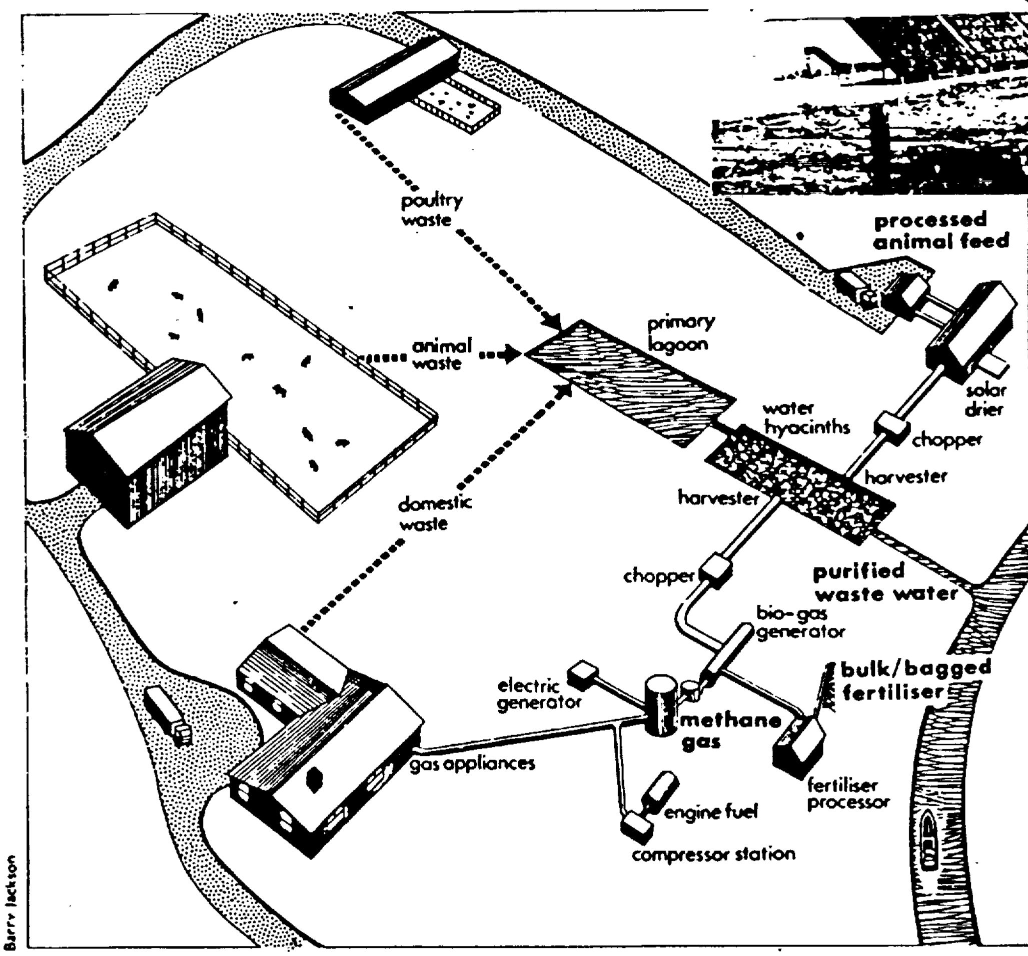


Figure 1 *Composition of sewage-grown water hyacinth*

	Per cent dry weight
Carbon	32 — 35
Hydrogen	5·4 — 5·8
Nitrogen	2·8 — 3·5
Potassium	2·0 — 3·5
Sodium	1·5 — 2·5
Calcium	0·6 — 1·3
Phosphorus	0·4 — 1·0
Sulphur	0·3 — 0·4
Magnesium	0·2 — 0·3
Iron	0·03 — 0·05
Zinc	0·005 — 0·05
Manganese	0·005 — 0·008

had grown to over 400 000 hectares. The Corps of Engineers and the US Department of Agriculture are currently evaluating biological control in the form of micro-organisms and insects, combined with mechanical and chemical methods. But until recently no serious attempt was made to exploit fully the desirable qualities of *Eichhornia*.

We have been so busy trying to destroy this beautiful plant that we failed to recognise fully its potential value in pollution control, and as a source of energy, food and livestock feed, fertilisers and other products. Cursed for so many years, the water hyacinth is now beginning to gain respectability by offering relatively simple and economically attractive solutions to some of mankind's most pressing problems.

Remarkable nutrient uptake

The US National Aeronautics and Space Administration (NASA) has demonstrated the remarkable mineral and nutrient uptake of water hyacinths at its National Space Technology Laboratory (NSTL). Grown in warm, enriched domestic sewage *Eichhornia* produces over 17·8 tonnes of wet biomass per hectare per day. Such plants contain 17-22 per cent crude protein, 15-18 per cent fibre and 16-20 per cent ash; the chemical composition is shown in Figure 1. Growth rate studies suggest annual production rates of 212 metric tons of dried plant material per hectare.

Raw sewage from small communities in South Mississippi contains an average of 35 milligrams per litre of nitrogen

Figure 2 *Effects of treating secondary sewage effluent (after primary filtration to remove gross solids) in an NSTL 0·28 hectare lagoon containing 6·8 million litres. The flow rate varied from 437 000 to 1 893 000 litres/day*

	Total Suspended Solids mg/l		Biochemical Oxygen Demand mg/l	
	inflow	outflow	inflow	outflow
Baseline data before addition of water hyacinths (May 1975)	31	49	22	32
Data after addition of water hyacinths				
Jul 1975*	33	7	27	11
Aug 1975*	35	13	26	5
Sep 1975*	43	6	22	7
Oct 1975***	48	9	25	7
Nov 1975***	50	10	29	15
Dec 1975****	52	24	32	24
Jan 1976**	47	16	57	24
Feb 1976**	67	25	135	30
Mar 1976***	50	25	70	28

* Flow Rate 437 000 litres/day
** Flow Rate 870 000 litres/day
*** Flow Rate 1 059 000 litres/day
**** Flow Rate 1 892 500 litres/day

and 10 mg/l of phosphorus. On this basis, a half-hectare lagoon covered with water hyacinths, with a minimum sewage retention time of two weeks, should be able to purify to acceptable levels the daily wastes of 1000 people. And as the field data in Figure 2 shows, an experimental water hyacinth lagoon did indeed reduce pollutant levels by 75-80 per cent.

Water hyacinths could also prove useful in treating effluents polluted with toxic heavy metals. In static laboratory experiments, *Eichhornia* rapidly absorbed gold, silver, cobalt, strontium, cadmium, nickel, lead and mercury. Ninety-seven per cent of the cadmium and nickel was concentrated in the roots within 24 hours—though the roots constitute only 18 per cent of the total dry weight. Water hyacinths can also absorb or metabolise phenols and other trace organic compounds of the type commonly found in the drinking water supplies of many large cities.

At NSTL, we now have a water hyacinth chemical waste filtration system consisting of a zig-zag canal 330 metres long, 6·4 metres wide and 0·8 metres deep. It contains 1 041 000 litres of water, with a surface area of 0·2 hectares, and receives 95 000 litres per day of chemical and photo lab waste.

We stocked the canal with water hyacinths in May 1975, three weeks after chemical waste had been diverted into the canal. Figure 3 illustrates how effective water hyacinths were in removing organic pollutants and trace quantities of heavy metals, which would otherwise have polluted the receiving streams.

Because of their high protein and mineral content, water hyacinths also show considerable promise as an animal feed supplement. The University of Florida has successfully fed water hyacinth silage to large animals, while at NSTL we have made a water hyacinth meal by drying whole green plants to moisture contents of less than 15 per cent. This can provide a 10-20 per cent supplement to the diet of beef cattle; beyond this amount animals can suffer from a mineral imbalance due to the high levels of potassium, iron and magnesium normally found in water hyacinths.

Water hyacinth meal is a good organic fertiliser and soil conditioner, too, because of its high nitrogen and mineral content. Its high moisture retention properties would improve the condition of sandy soils, and water hyacinths can be spread directly on the ground as a mulch or compost.

Natural gas substitute

Water hyacinths can also be used to produce biogas containing 60-80 per cent methane, which is a promising substitute for natural gas. Our research shows that 374 litres of biogas can be produced per kilogram of dried water hyacinth; its fuel value is 21 000 BTU per cubic metre, compared with 31 600 BTU/cu m for pure methane.

A continuous supply of water hyacinths can be grown in domestic sewage lagoons where, as we have seen, they can also perform a valuable anti-pollution function. A hectare of water hyacinths fed on sewage nutrients can yield 0·9-1·8 tonnes of dry plant material per day. This biomass can produce 220-440 cu m of methane with a fuel value of 7-14 million BTU. In addition, the sludge that remains after fermentation is a useful fertiliser, because it retains most of the nitrogen, all of the phosphorus, and other minerals.

The clogging of major waterways by water hyacinths is a serious problem in many developing countries. Although these weeds generally have a lower protein content than cultivated water hyacinths, they are still very useful as a substrate for biogas production. The Sudanese Government (with the assistance of NASA through the US National Academy of Sciences) is experimenting with small-scale digestors to process the thousands of tons of water

Figure 3 *A 0·2 hectare canal covered with water hyacinths substantially reduced organic, nutrient and heavy metal pollutant from laboratory effluent. (Figures are in milligrams per litre, and cover July 1975.)*

	Organic carbon	BOD	Total disolved solids	Nitrogen	Phos-phorus	Silver
Inflow	75	33	380	2·36	0·48	0·99
Outflow	13	3·6	212	0·43	0·08	0·001

hyacinths mechanically harvested from the White Nile.

The water hyacinth is a warm weather plant which flourishes in tropical and subtropical regions, but its range could possibly be extended by utilising the heat from raw sewage, by greenhouse-type canopies, or by using thermal discharges from industrial operations and power plants. Using the hot water from nuclear power plants is especially appealing, because the plants could act as an added safety filtration system for removing radioactive elements. At NSTL we are also experimenting with the use of duckweeds for sewage filtration during cold months when the water hyacinth is temporarily inactive.

Experiments at NASA's National Space Technology laboratories have shown, therefore, that in tropical and subtropical conditions water hyacinths have the ability to absorb organics, heavy metals, nutrients, and other chemical elements from wastewater while producing large quantities of plant material. This water hyacinth biomass, when grown in sewage free of toxic metals, is a potential source of protein fertiliser, methane gas and other valuable products. □